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A taxonomic study of the Pteridophyta of the Hawaiian Islands—

WINIFRED J. ROBINSON

(WITH PLATES 18–20)

The following paper is a partial result of the study of ferns and fern allies of the Pacific Islands, which was begun several years ago under the direction of the late Professor Lucien M. Underwood, whose design was to combine the regional taxonomic studies of a number of workers in a comprehensive report which should include ecological and morphological features as well. To the writer was assigned the taxonomic study of the Hawaiian fern flora.

The Hawaiian Islands lie at the crossroads of the Pacific, latitude 18° 55′–22° 15′ north, longitude 154° 50′–160° 30′ west, more than two thousand miles from San Francisco and about the same distance from the nearest islands to the southwest. They are farther from the mainland than any other group of islands of the same extent; and while a geodetic map shows that they have arisen by volcanic action through a fissure in the earth's crust, which extends from northwest to southeast, there is nothing to indicate that they were ever connected by a chain of islands with Japan, and there is very little in common in the floras of Japan and Hawaii. Hence their isolation must have been as complete through the ages as it is now. With the exception of coral limestone along the shore and a little sandstone and sedimentary rock, the soil is uniformly of basaltic origin. Kauai, geologically the oldest island of the group, about 2,000 m. high at its highest point, is most eroded and deserves its name of the garden island. Hawaii, with two snow-capped peaks, Mauna Kea and Mauna Loa, each nearly 5,000 m. high, and with its active volcano, Kilauea, is still in the making. The ridges are steep and the valleys narrow in all the islands. As a rule the northeast side of the island is covered with rain forest, while the southwest or lee side is arid because of the direction of the prevailing winds.

These winds together with the ocean currents make the temperature of the Hawaiian Islands several degrees lower than that of the West Indies, which are in the same latitude. At sea level it ranges from 16° to 30° C., while at an elevation of 365 m. it is about 20° C.

There are few wild plants in the islands that seem to owe their origin to northwest America, though a pine log of great size, evidently brought by the North Pacific Drift Current, has been known to reach the island of Maui. A correspondence between a number of South American and Hawaiian forms has been traced among flowering plants, but the affinities of the ferns seem to be with those of the islands to the southwest rather than with those of the mainland, while a large number of species are endemic. The extreme lightness of the spores makes their suspension in currents of air for long periods possible, and also may account for their transfer over great distances. In prehistoric times the journey of two thousand miles from the Society Islands was probably made several times in open boats, and since ferns were used in the religious rites of the islanders, some species may have been introduced in this way.

The material for this study consisted of the collections in the herbarium of the New York Botanical Garden (indicated by C), that of the Royal Botanical Garden at Berlin, Germany (indicated by B), the Bernice Pauahi Bishop Museum at Honolulu, H. I. (indicated by BM), the National Herbarium at the Smithsonian Institution, Washington, D. C. (indicated by N), and the herbarium of Vassar College, Poughkeepsie, New York (indicated by V). In a few cases comparisons have been made at Kew through the kindness of Mrs. N. L. Britton of the New York Botanical Garden (indicated by K). The writer spent seven weeks in the Hawaiian Islands, in the summer of 1909, in collecting ferns and observing ecological factors of their habitat.

When Captain Cook made his last South Sea voyage in 1776–9, during which he discovered the Hawaiian Islands, he was accompanied by David Nelson, who made collections of ferns and other plants, now preserved in the herbarium at Kew, that of the Linnean Society of London, and that of the British Museum. Landings were made upon Kauai and Nihau in January 1778, but the men did not remain long enough to permit exploration at any considerable distance from the shore. In November 1778 Captain Cook returned and spent ten weeks in cruising about Maui and Hawaii, making frequent landings, hence it is probable that the greater portion of Nelson's collection is from these islands.

At Kew there are also preserved specimens from the collections of Archibald Menzies, surgeon and naturalist upon Vancouver's voyage of 1790–95. Some of his specimens have reached the herbarium of the New York Botanical Garden by exchange with Kew. Vancouver's policy in dealing with the natives was so just that he secured their confidence and his men were able to explore freely. He spent about four months upon the islands.

In 1816–17 Albert Chamisso, while on the voyage of the Romanzoff, made collections of plants in Oahu and published his notes and descriptions of new species in Linnaea. His collections are at Berlin, in the herbarium of the Royal Botanical Gardens.

In 1819 Charles Gaudichaud, botanist of the French Corvette l'Uranie under Captain Freycinet made collections upon the islands, and published his account of plants in Botanique du Voyage d'Uranie, in 1830 (1826 according to the title page). He returned to the Hawaiian Islands in 1826 as botanist on the Bonite, but the only record of his collections consists of a few plates with no adequate descriptions or notes as to localities where the plants were found.

James Macrae, afterward superintendent of the Ceylon Botanical Gardens, made collections in the Pacific Islands and in South America between the years 1824 and 1826. His collections have been variously distributed by exchange and appear in herbaria in Great Britain, the Continent, and America.

In 1826–7 George T. Lay and Alexander Collie, the collectors with Captain Beechey on the voyage of the Blosssom, secured the specimens from which Hooker and Arnott made their report of the Botany of Captain Beechey's Voyage, 1830–41.

In 1833 David Douglas, sent out by the London Horticultural Society, made valuable collections of Hawaiian ferns, which are preserved in the herbaria of Hooker, Bentham, and Lindley. Douglas met his death in Hawaii by falling into a pit which was intended to entrap animals.

The United States Exploring Expedition under Captain Wilkes visited the Hawaiian Islands in 1840. Brackenridge, the botanist of the expedition, published his descriptions of ferns as a separate volume of the report of the expedition, but unfortunately the edition with the exception of about a dozen copies was destroyed by fire. A nearly complete set of his specimens is in the U. S. National Herbarium at Washington, D. C., and the collection is well represented at the New York Botanical Garden.

Rev. J. Diell, seaman's chaplain at Honolulu, aided Brackenridge materially in his collecting and also did much independently.

On the Galathea Expedition, 1845–7, sent out from Denmark, Didrichsen was the botanist. The larger part of his collections are at Copenhagen; some specimens, however, have reached other herbaria by exchange.

Between 1851 and 1855 Remy made collections for the Paris Museum, some of which may now be seen in the Gray Herbarium at Cambridge, Massachusetts.

In 1864 and 1865 Horace Mann with Dr. William T. Brigham, now Director of the Bernice Pauahi Bishop Museum at Honolulu, spent a year in botanizing over the five larger islands. With the aid of Professor Asa Gray, Mann made an enumeration of the plants found on the islands, which included one hundred and thirteen species of ferns. One set of these specimens is at the Museum in Honolulu and another at Cornell University, Ithaca, New York. Some of the numbers appear in other herbaria.

Many residents in the islands have been interested in the fern flora and have made large collections. The Reverend John M. Lydgate, of Lihue, Kauai, civil engineer and botanist, as well as clergyman, published an enumeration of Hawaiian ferns in 1873, when in college at Oberlin. His later collections have been contributed to Dr. W. Hillebrand's herbarium, now in Berlin. Many of the specimens from Kauai in the Berlin herbarium were collected by Mr. Valdemar Knudsen. The late D. D. Baldwin, at one time professor at Punahou College, has made large collections upon Oahu and Maui. Rev. Edward Bishop was an ardent collector also.

In 1883 Edward Bailey published "Hawaiian Ferns, a Synopsis," a small manual, now out of print. It contained descriptions of six new species.

Dr. William Hillebrand spent twenty years in the Hawaiian Islands, during all of which time he was an enthusiastic botanist. A part of the manuscript of his Flora of the Hawaiian Islands was with the printer at the time of his death, in 1887, and the work was published the following year by his son, Dr. W. F. Hillebrand, now Chief Chemist, Bureau of Standards, Washington, D. C. The herbarium of Dr. William Hillebrand was bequeathed to the Royal Botanical Museum, at Berlin, Germany. The accuracy of his descriptions was shown by the comparison of his specimens with the diagnoses in his Flora. He included one hundred and fifty-five species and many varieties of pteridophytes.

Mr. A. A. Heller, now of the College of Agriculture, Reno, Nevada, made a botanical exploration of Kauai and Oahu in 1895–6 under the auspices of the Minnesota State Geological Survey. The larger part of the collection is at the herbarium of the University of Minnesota, but duplicates have been distributed to several of the larger American institutions and to Kew. A complete set of his vascular cryptogams is at the New York Botanical Garden, as it was sent to Professor L. M. Underwood for determination. The report included one hundred and sixteen species, six of which were new.

In the following summary of the taxonomic study of Hawaiian ferns, diagnoses of the larger groups and also of genera have been given with keys to species, but descriptions of species already published elsewhere have been omitted.

The method in this study has been to examine the specimens as if they represented undescribed species, then to compare them with types so far as possible and with published descriptions. It has been attempted to give the name first used for the plant in Linnaeus' Species Plantarum or the name first published subsequent to 1753.

The writer is indebted to Dr. N. L. Britton, Director of the New York Botanical Garden, for suggestions and criticism, to Mr. William R. Maxon of the U. S. National Herbarium, Smithsonian Institution, Washington, D. C., for the loan of material and helpful criticism, and to Dr. J. H. Barnhart, Librarian of the New York Botanical Garden, for suggestions and criticism as to form, also to Professor A. Engler, Director of the Royal

Botanical Gardens of Berlin, Germany, for permission to study the Hawaiian ferns in the herbarium of the Royal Museum.

PTERIDOPHYTA

Plants (sporophytes) with well-defined vascular tissue, which in the homosporous series produce spores that grow into gametophytes which may be monoecious or dioecious, and in the heterosporous series produce megaspores and microspores; of these the megaspores grow into gametophytes that bear female organs (archegonia), the microspores into gametophytes that bear male organs (antheridia). As the result of the union of the egg cell in the archegonium and a motile male cell (antherozoid) from an antheridium, the sporophyte, ordinarily considered the plant, develops. Reproduction by some form of budding occurs both in the gametophyte and the sporophyte stage of the life history of many species.

Spores in capsules (sporocarps) borne upon the rhizome.	1. SALVINIALES.
Spores borne upon some aerial member of the plant.	
Sporangia not borne in the axils of scalelike leaves.	
Vernation circinate.	
Sporangia separate.	4. FILICALES.
Sporangia coalescent (synangia).	3. MARATTIALES.
Vernation erect or inclined.	2. OPHIOGLOSSALES.
Sporangia borne in the axils of scalelike leaves; these either distant or forming compact strobili.	5. LYCOPODIALES.

1. SALVINIALES

Aquatic or subaquatic plants with horizontal, creeping or floating stems, which bear sporocarps containing megaspores or microspores or both; leaves various.

Plants floating; leaves with entire or 2-lobed blades folded in vernation.	1. SALVINIACEAE.
Plants rooting in the mud; leaves filiform or 2–4-foliate, circinate in vernation.	2. MARSILEACEAE.

1. SALVINIACEAE

Small floating plants, with a more or less elongated, sometimes branching axis. Leaves apparently 2-ranked. Sporocarps 2 or more borne upon a common peduncle; megaspores and microspores in separate sori.

Azolla sp. recently introduced to prevent the breeding of mosquitoes in the ditches along the rice fields.

2. MARSILEACEAE

Perennial plants; leaves 2 or 4-foliate; sporocarps on peduncles which arise with the petioles of leaves or separately from the rootstock and bear megaspores and microspores in the same sorus.

Type species:* *Marsilea quadrifolia* L.

MARSILEA VILLOSA Kaulf. Enum. 272. 1824

TYPE LOCALITY: Oahu, Hawaiian Islands.

DISTRIBUTION: In taro patches, Hawaiian Islands.

SPECIMENS EXAMINED: Hawaiian Islands, *Chamisso* B; *Gaudichaud* B; *Remy* B.

M. villosa is closely allied to *M. vestita* Hook. & Grev. from Oregon and California. Brackenridge referred the American plant to *M. villosa*, but the specimens examined indicate that the Hawaiian plant is a larger and less hairy species than that figured by Hooker and Greville (Ic. Fil. 159. 1829). All specimens in the Berlin herbarium are sterile; Remy's specimen has narrower leaflets and a more compact rootstock than Chamisso's.

SPECIES INQUIRENDA

Marsilea crenulata Desv. Reported by Hillebrand (Fl. Haw. Is. 651. 1888) as collected in Oahu and preserved in the Godet Herbarium. This herbarium is unknown to Dr. W. T. Brigham, director of the Bishop Museum at Honolulu. No specimen was found by the writer in the Berlin herbarium.

2. OPHIOGLOSSALES

Herbaceous, usually succulent plants consisting of a fleshy rootstock with fibrous or fleshy roots and one to several leaves, the latter erect or pendent, non-articulate, simple, lobed, or compound, the blade sessile or stalked; sporophyls simple or ternately compound, arising from the sterile leaf or from the rootstock. Sporangia formed each from a group of epidermal and subepidermal cells, dehiscing by a transverse slit. Prothallia subterranean, usually achlorophyllous and nourished by an endophytic fungus.

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* According to the American code of nomenclature the type species of the genus *Marsilea* L. is *Marsilea natans* L. which is based upon *Salvinia* Mich. Nov. Pl. Gen. *pl. 58.* 1729. Under the American code, therefore, the name *Marsilea* L. should be used for *Salvinia* (Micheli) Adans., while the present genus should be called *Lemma* (B. Juss.) Adans.

OPHIOGLOSSACEAE

Characters of the order.

Leaf blade and sporophyl both ternately compound; veins free.	1. *Botrychium.*
Leaf blade simple, sporophyl a distichous spike; veins reticulate.	
Plants terrestrial; leaf blades petiolate.	2. *Ophioglossum.*
Plants epiphytic; leaf blades sessile.	3. *Ophioderma.*

1. BOTRYCHIUM Sw. Jour. Bot. Schrad. 1800^2: 110. 1801

Terrestrial plants; rootstock short, fleshy, erect; roots clustered, fleshy; sterile leaves 1–3-pinnately compound or decompound; veins free; sporophyls ternately compound; sporangia separate, spherical, sessile, pinnately arranged.

Type species: *Osmunda Lunaria* L.

Botrychium subbifoliatum Brack. Fil. U. S. Expl. Exp. 317. 1854

Type locality: Hawaii, District of Puna.

Distribution: On the ground in wet forests, Hawaiian Islands.

Illustrations: Brack. Fil. U. S. Expl. Exp. *pl. 44.* 1854. Plate 18.

Specimens examined: Hawaii, District of Puna, *Wilkes Expedition* (type) N; Oahu, *Lydgate* B; Kauai, *Forbes 262* BM; *Wawra 2061* C; *Remy 62* B; Hawaiian Islands, *Baldwin 114* B, C, N.

The sterile leaf is always asymmetrical, one of the basal pinnae arising above the other.

2. OPHIOGLOSSUM L. Sp. Pl. 1062. 1753

Terrestrial plants; rootstock erect, less than 1 cm. in height; roots fleshy; leaves glabrous; leafstalk fleshy, not articulate; veins anastomosing, with occasional free included veinlets; sporophyl a pedunculate spike, arising from the base of the expanded blade; sporangia in two rows, coalescent.

Type species: *Ophioglossum vulgatum* L.

Ophioglossum concinnum Brack. Fil. U. S. Expl. Exp. 315. 1854

Type locality: Sand hills, near Wailuku, Maui, Hawaiian Islands.

DISTRIBUTION: On ground, appearing after rains; often near the seashore or in soil that has been taken from the shore; Hawaiian Islands.

ILLUSTRATION: Brack. Fil. U. S. Expl. Exp. *pl. 44. f. 1.* 1854.

SPECIMENS EXAMINED: Maui, *Hillebrand* B; Oahu, *Forbes* BM; *Remy* B; Hawaiian Islands, *Baldwin 113* B, C.

The point of divergence between the leaf and sporophyl is on the petiole in *O. nudicaule* Sw. (Syn. Fil. *pl. 4. f. 2.* 1806), while in *O. concinnum* Brack. it is at the base of the blade; the blade is ovate in *O. nudicaule* rather than elliptical as in *O. concinnum*, and there is no trace in the Hawaiian plant of the midrib mentioned for *O. ellipticum* (Hook. & Grev. Ic. Fil. *pl. 40.* 1831). All these forms, however, are closely related.

3. OPHIODERMA (Bl.) Endl. Gen. Pl. 66. 1836

Epiphytic plants; rootstock erect, less than 1 cm. high; roots fleshy; leaves not articulate, strap-shaped, sessile, fleshy, brittle; venation reticulate, without free included veinlets; sporophyl a two-ranked spike of coalescent sporangia, arising from the middle of the blade.

Type species: *Ophioglossum pendulum* L.

OPHIODERMA PENDULUM (L). Presl, Suppl. Tent. Pterid. 56. 1845
Ophioglossum pendulum L. Sp. Pl. ed. 2. 1518. 1763.

TYPE LOCALITY: Amboina, Molucca Islands.

DISTRIBUTION: On trees or fallen logs, at elevations of 600–1,500 m.; Asia, Australia, Polynesia.

ILLUSTRATIONS: Hook. & Grev. Ic. Fil. *pl. 19.* 1831; Rumpf. Amb. *pl. 37. f. 3.* 1741.

SPECIMENS EXAMINED: Hawaii, *Robinson 212* V; *Wilkes Expedition* N; Maui, *Lichtenthaler* N; *Robinson 304* V; *320* V; Oahu, *Heller 2217* C, N; *Robinson 8* V; *43* V; *111* V; *115* V; *Safford 920* N; Kauai, *Robinson 429* V; *443* V; Hawaiian Islands, *Baldwin 112* B, C; *Miss Sessions* C; ex Herb. John Donnell Smith *618* N.

3. MARATTIALES

Plants herbaceous, consisting of a fleshy or tuberous rootstock, soft fleshy roots, and cespitose, stipulate, bipinnate to tripinnate leaves, which are articulate upon the stem and circinate in vernation; veins free; sporangia developed from a group of epidermal and subepidermal cells, separate or coalescent, in the latter case forming boat-shaped or circular synangia. Prothallia green, thalloid, large.

MARATTIACEAE

Characters of the order.

MARATTIA Sw. Prod. Fl. Ind. Occ. 128. 1788

Rootstock tuberous, starchy; leaf blades deltoid, dark green, thick, glabrous, bipinnate to tripinnate; stipules two, fleshy, at the base of the fleshy leafstalk; venation free; sporangia near the ends of the veins, coalescent, forming synangia upon a slightly elevated receptacle; these in some species subtended by a pseudo-indusium.

Type species: *Marattia alata* Sw.

MARATTIA DOUGLASII (Presl) Baker; Hook. & Baker, Syn. Fil. 441. 1868

Marattia alata Hook. & Arn. Bot. Beech. 102. 1832. Not *M. alata* Sw. 1788.

Stibasia Douglasii Presl, Suppl. Tent. Pterid. 16. 1845.

Gymnotheca Douglasii Moore, Ind. Fil. 121. 1857.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: In moist, shady localities, above 600 m. elevation, Hawaiian Islands.

ILLUSTRATION: Vriese, Mon. Marat. *pl. 4.* 24. 1853.

SPECIMENS EXAMINED: Hawaii, *Robinson 202* V; Maui, *Robinson 329* V; Oahu, *Diell* C; Kauai, *Heller 2770* C, N; *Lichtenthaler* N; Hawaiian Islands, *Baldwin 111* C, N; *Wilkes Expedition* C; *Hitchcock* C; ex Herb. Mt. Holyoke College C; ex Herb. John Donnell Smith N.

The fleshy tubers taste somewhat like a turnip and are eaten either raw or baked by the native Hawaiians.

4. FILICALES

Plants terrestrial or epiphytic (aquatic in Ceratopteridaceae), varying in habit from minute herbaceous forms to arboreous forms; sporangia developed from a single epidermal cell, mainly upon the under surface of the leaf, in clusters (sori) upon the veins, or within marginal indusia, or less commonly, scattered over the entire lower surface or upon non-foliose sporophyls. Indusia various or wanting. Prothallia chlorophyllous, thalloid.

- Sporangia borne in a distichous spike; sterile leaves slender, grasslike. — 1. SCHIZAEACEAE.
- Sporangia associated in indusiate or non-indusiate sori or scattered over the lower surface of the leaf.
  - Leaves pseudo-dichotomous, usually with a bud between the paired divisions, giving the appearance of indefinite growth; sori non-indusiate, small, circular. — 2. GLEICHENIACEAE.
  - Leaves simple, pinnately divided, or ternately divided.
    - Sori valvate or tubular.
      - Sori valvate, the outer valve formed by a coriaceous outgrowth from the margin of the leaf, dorsal upon the veins; plants arboreous. — 3. CYATHEACEAE.
      - Sori valvate or tubular, not coriaceous; terminal upon the veins; plants delicate, mostly epiphytic. — 4. HYMENOPHYLLACEAE.
    - Sori not valvate or tubular; indusium various or absent. — 5. POLYPODIACEAE.

1. SCHIZAEACEAE

Plants of diverse form and habit, including xerophilous forms with simple leaves and climbing plants with lobed or divided leaves. Sporangia borne singly or in rows on more or less specialized terminal segments, or upon the very slender non-foliose pinnae, indusiate or non-indusiate; annulus subapical, distally contracted; dehiscence longitudinal. Prothallia foliose or filamentous and branched.

SCHIZAEA J. E. Smith, Mém. Acad. Turin 5: 419. 1793

Rootstock short, upright, covered with dark brown scales; leaves linear, grasslike; sporophyl consisting of a long slender stalk and a digitate fertile portion folded upon the midrib; sporangia borne in two rows upon each division.

Type species: *Schizaea dichotoma* J. E. Smith.

SCHIZAEA ROBUSTA Baker; Hook. & Baker, Syn. Fil. ed. 2. 429. 1874

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: At high elevations in marshes and occasionally in exposed localities, Hawaiian Islands.

SPECIMENS EXAMINED: Oahu, *Forbes 1038* BM; *Lichtenthaler* N; *Mann & Brigham 475* N; *Wilkes Expedition* N; Kauai, *Heller 2246* C, N; *Robinson 419* V; *452* V; Hawaiian Islands, *Baldwin 115* C, N; *Baldwin* (ex Herb. Hillebrand) C; *Baldwin* (ex Herb. Mt. Holyoke College) C.

This is the species wrongly referred by Brackenridge (Fil. U. S. Expl. Exp. 302. 1854) to *S. australis* Gaud., a plant from the Falkland Islands, described by Gaudichaud (Ann. Sci. Nat. 5: 98. 1825).

Heller (Minn. Bot. Stud. 1: 789. 1907) says: "The first specimens were collected at an elevation of perhaps 762 m., on Konahuanui, Oahu, on a little spot in clay formation. The plants were small and stunted. It was found on the opposite side of the valley on the slope of Waiolani, at the same elevation. Near the Wahiawa bog, on Kauai, large and beautiful specimens were obtained." Mr. C. N. Forbes' specimen (*Forbes 1038* BM) collected at the extreme western ridge of Konahuanui, "a dry ridge in broad sunlight," is small and stunted though it has developed sporangia, while specimens from the Wahiawa bog above McBride's mountain house (*Robinson 419* V and *452* V) are large and fine.

2. GLEICHENIACEAE

Terrestial, xerophilous plants, with erect or creeping rootstocks. Leaves non-articulate, distant or cespitose, mostly consisting of an erect or ascending primary leafstalk of indeterminate growth, forking into one to several opposite divisions, these simple and determinate or one to several times dichotomous. Sori dorsal or terminal upon the veins, non-indusiate; sporangia sessile, subglobose to pyriform; annulus nearly complete, obliquely transverse; dehiscence vertical.

The family Gleicheniaceae is represented by several species of the genus *Dicranopteris*, which form nearly impenetrable thickets upon the mountain sides and sometimes in the valleys also. The attachment of the roots to the thin soil is very insecure and the man or beast that ventures to step upon the seemingly solid mass, where it has overgrown the trail in the mountains, may feel it give way, allowing him to slip far down the steep slope. *Dicranopteris* is known locally as stag-horn fern and is a pest in the cattle-raising districts, as stock refuse to graze upon it.

DICRANOPTERIS Bernh. Neues Jour. Bot. Schrad. 1^2: 38. 1806

Rootstock creeping, much branching, 0.5–1 cm. in diameter; leafstalk 1–2 m. high, not articulated to the rootstock; rachis of indeterminate growth, bearing opposite lateral branches in acropetal succession, these simple or repeatedly forked; included buds sometimes developing axes similar to the primary; ultimate divisions pectinate, pinnate, or bipinnate; veins free; sori dorsal upon the veins, non-indusiate; sporangia sessile; annulus obliquely transverse, the dehiscence vertical.

Type species: *Polypodium pectinatum* Thunb.

Ultimate divisions bipinnate, the leafstalk not forked.
  Pinnules sessile, the lower segments lobed and overlapping the rachis; leafstalk noticeably scaly. *D. glauca.*
  Pinnules stalked, the lower segments entire; leafstalk with few scales. *D. glabra.*
Ultimate divisions (pinnae) pectinate, in pairs; the leafstalk once or several times forked.
  A pair of accessory, deflexed, equal or unequal pinnae borne at all except the ultimate forkings of the leafstalk; veins 2–5-forked; segments mostly emarginate, connected by wing along rachis; sori 5–12-sporangiate.
    Segments densely tomentose when young, somewhat less so with age; texture rigid; emarginate character of pinnules constant; sori mostly 8-sporangiate or less. *D. emarginata.*
    Segments glabrous or nearly so; texture chartaceous; emarginate character of pinnules not constant; sori usually 12-sporangiate. *D. linearis.*
  Accessory pinnae wanting; segments not emarginate, nearly or quite free; rachis scaly; veins mostly once forked; sori 2–5-sporangiate. *D. owhyhensis.*

DICRANOPTERIS GLAUCA (Thunb.) Underw. Bull. Torrey Club **34**: 249. 1907

Polypodium glaucum Thunb.; Houtt. Nat. Hist. **14**: 177. 1783.
Mertensia glauca Sw. Sv. Vet.-Akad. Handl. II. **25**: 177. 1804.

Gleichenia longissima Blume, Enum. Pl. 250. 1828.
Mertensia pinnata Kunze, Anal. Pterid. 6. 1837.
Mertensia excelsa J. Sm. Lond. Jour. Bot. 2: 381. 1843.
Gleichenia glauca Hook. Sp. Fil. 1: 4. 1844.
Hicriopteris speciosa Presl, Epim. 27. 1849.

TYPE LOCALITY: Java.

DISTRIBUTION: China, Japan, Malaysia, Tropical Australia, and Polynesia.

ILLUSTRATION: Hook. Sp. Fil. *pl. 3B.* 1844.

SPECIMENS EXAMINED: Maui, *Bailey* C; Molokai, *Hillebrand* B; Oahu, *Hillebrand* B; *Macrae* B; *Robinson 501* V; *504* V; Kauai, *Hillebrand* B, C.

D. glauca is found in fruit somewhat rarely. Both the bipinnate species are less common than *D. linearis* and grow at higher elevations.

DICRANOPTERIS GLABRA (Brack.) Underw. Bull. Torrey Club 34: 249. 1907

Mertensia glabra Brack. Fil. U. S. Expl. Exp. 292. 1854.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Above 600 m. on wet mountain slopes, Hawaiian Islands.

SPECIMENS EXAMINED: Oahu, *Hillebrand* B; *Robinson 55* V; Kauai, *Forbes 107* BM; *Heller 2613* C; Hawaiian Islands, ex Herb. Eaton C.

Dicranopteris emarginata (Brack.) comb. nov.

Mertensia emarginata Brack. Fil. U. S. Expl. Exp. 297. 1854.

TYPE LOCALITY: Hawaii.

DISTRIBUTION: Open mountain ridges, Hawaiian Islands.

ILLUSTRATIONS: Brack. Fil. U. S. Expl. Exp. *pl. 42. f. 1a, 1b.* 1854.

SPECIMENS EXAMINED: Oahu, *Robinson 40* V; Hawaiian Islands, *Hillebrand* K; *Wilkes Expedition* C.; ex Herb. Eaton C; *Lindley* C.

DICRANOPTERIS LINEARIS (Burm.) Underw. Bull. Torrey Club 34: 250. 1907

Polypodium lineare Burm. Fl. Ind. 235. 1768.
Polypodium dichotomum Thunb. Fl. Jap. 338. 1784.

Mertensia dichotoma Willd. Sv. Vet.-Akad. Handl. II. **25**: 167. 1804.
Dicranopteris dichotoma Bernh. Neues Jour. Schrad. 1^2: 38. 1806.
Gleichenia linearis Clarke, Trans. Linn. Soc. II. **1**: 428. 1880.

TYPE LOCALITY: Java.

DISTRIBUTION: Forming thickets at from 200–1,000 m. elevation, tropical countries.

ILLUSTRATIONS: Burm. Fl. Ind. *pl. 67. f. 2.* 1768; Thunb. Fl. Jap. *pl. 37.* 1784.

SPECIMENS EXAMINED: Hawaii, *Hillebrand* B; *Robinson 240* V; Maui, *Bailey* B, C; *Robinson 316* V; Oahu, *Didrichsen 3772* C; *Forbes* BM; *Robinson 24* V; Kauai, *Forbes 80* BM; *Heller 2761* C; Hawaiian Islands, *Baldwin 1* C; *Wilkes Expedition* C; ex Herb. Eaton C; ex Herb. Mt. Holyoke College C.

Dicranopteris owhyhensis (Hook.) comb. nov.

Gleichenia owhyhensis Hook. Sp. Fil. **1**: 9. 1844.
Mertensia hawaiiensis Brack. Fil. U. S. Expl. Exp. 295. 1854.
Gleichenia hawaiiensis Hilleb. Fl. Haw. Is. 544. 1888.

TYPE LOCALITY: Byron Bay, Oahu, Hawaiian Islands.

DISTRIBUTION: At elevations of 1,500–2,000 m., rare; Hawaiian Islands.

SPECIMENS EXAMINED: Maui, *Bailey* C; *Hillebrand* B; Oahu, *Baldwin 9* B; *Hillebrand* B; *Heller* C; Kauai, *Hillebrand* B; *Robinson 407* V; *410* V; Hawaiian Islands, *Baldwin 2* C; *Macrae* B, C.

The name is derived from an early spelling of Oahu; the type was collected upon this island by Macrae.

3. CYATHEACEAE

Mainly arboreous plants of the humid elevated regions of the tropics; rootstock stout and erect or decumbent; leaves cespitose, usually twice or more pinnate, rarely simple, articulate or non-articulate; leaf blades mostly one to several meters long; sori globose, dorsal or terminal upon the veins, indusiate or non-indusiate; sporangia usually numerous, ovoid, the annulus complete and oblique, with or without a definite orifice; dehiscence horizontal.

The family Cyatheaceae is represented in the Hawaiian flora by a single genus, *Cibotium*, which forms a conspicuous part of the fern forest in the region of the active volcano Kilauea, on Hawaii, and appears above 600 m. elevation on the other islands, though, doubtless, its size is greatest in the forests below Kilauea, in Puna and Olaa. Three species are associated in this locality, and these apparently intergrade.

Trunks of *Cibotium* have been used to make fences by placing them side by side like a palisade, and as they regenerate their crowns they make a most effective enclosure. On Mr. Snow's estate at Glenwood, 22 miles from Hilo, walks have been made of boards sawed from fern trunks, probably of *C. Menziesii*, which contain some boards 1 m. in width. On this estate and on the Hitchcock place adjoining, *C. Menziesii* growing in the open has attained a height of 16 m. or more.

The wooly scales at the base of the leafstalks, known commercially as pulu, were used formerly to a considerable extent as stuffing for mattresses, and the pulu-gatherers were ruthless in their destruction of old trees to obtain this commodity. Now, however, pulu has fallen into disuse and is no longer exported.

CIBOTIUM Kaulf. Jahrb. Pharm. 21: 53. 1820

Pinonia Gaud. Ann. Sci. Nat. 3: 507. 1824.

Rootstock usually arborescent with numerous large, chaffy scales at the apex; leafstalks not articulate; blades deltoid-ovate, bipinnate to quadripinnate, the pinnules stalked; sori valvate capsules, consisting of a cuplike outgrowth from the margin of the lobe of the pinnule and the indusium, which forms a lidlike covering. Sporangia stalked.

The leaves of all Hawaiian species are tripinnate.

Type species: *Cibotium Chamissoi* Kaulf.

Caudex 4–8 m. high; leafstalk 3–4 m. long, covered with soft, brown scales at the base, with black, hairlike scales above; blades 3–4 m. long; sinuses between the segments of the pinnules broad, shallow, often margined with sori; fertile veins mostly simple, usually 7 or less to a segment. *C. Menziesii.*

Caudex less than 3 m. high, usually about 2 m. high; leafstalk clothed at the base with soft, brownish scales, upper portion naked; blades less than 3 m. long; sinuses between segments of pinnules narrow, acute; fertile veins simple or once forked.

Lower surface of blade dull glaucous, for the most part strongly tomentulose; veins 6–8 to a segment, simple or forked. *C. Chamissoi.*

Lower surface of blade conspicuously glaucous, for the most part slightly tomentulose, becoming glabrous; veins 9–10 to a segment, usually 1–2-forked. *C. glaucum.*

CIBOTIUM MENZIESII Hook. Sp. Fil. 1: 84. 1844

Dicksonia Menziesii Hook. & Baker, Syn. Fil. 49. 1866.

TYPE LOCALITY: Oahu, Hawaiian Islands.

DISTRIBUTION: On ground at 600–1,250 m. elevation; usually found with lehue and other hardwood trees, in a damp forest; Hawaiian Islands.

ILLUSTRATION: Hook. Sp. Fil. 1: *pl. 29c.* 1844.

SPECIMENS EXAMINED: Molokai, *Hillebrand* B, C; Oahu, *Beechey* K, C; *Forbes* BM; *Robinson 707* V; Kauai, *Heller 2693* C; Hawaiian Islands, *Baldwin 5* B, C, N; *Wilkes Expedition* C.

The ohia-lehue (*Metrosideros villosa* Sm.) often succeeds *Cibotium* in the forest by germinating in the crown of the fern, sending down its roots along the moist trunk and finally shutting out the light entirely, so that in time the fern dies and the lehue is left with what is apparently a hollow and fissured trunk.

Heller 2590 may be a cross between *C. Menziesii* and *C. Chamissoi*, in which more of the dominant characters belong to the former than to the latter.

CIBOTIUM CHAMISSOI Kaulf. Berl. Jahrb. Pharm. 21: 53. 1820

Pinonia splendens Gaud. Ann. Sci. Nat. 3: 507. 1824.
Dicksonia splendens Desv. Prod. 318. 1827.
Cibotium pruinatum Mett. in Kuhn, Linnaea 36: 150. 1869.

TYPE LOCALITY: Oahu.

DISTRIBUTION: On the wooded slopes of mountains, at elevations of 600–1,200 m., Hawaiian Islands.

ILLUSTRATIONS: Kaulf. Enum. *pl. 1. f. 14.* 1824; Hook. Ic. Pl. 17: *pl. 1603.* 1886.

SPECIMENS EXAMINED: Hawaii, *Lichtenthaler* N; Oahu, *Beechey* B; *Bennett* B; *Chamisso* B; *Gaudichaud* B; *Heller 2898* C; *Robinson 35* V; *Safford 875* N; Kauai, *Heller 2600* C, K; *Knudsen 36* B; Molokai, *Hillebrand* B, C; Hawaiian Islands, *Baldwin* B; *Gaudichaud* B, C; *Lydgate* B; *Wilkes Expedition* C, N.

CIBOTIUM GLAUCUM (J. E. Smith) Hook. & Arn. Bot. Beech. 108. 1841

Dicksonia glauca J. E. Smith, in Rees, Cyc. 11. 1819.

TYPE LOCALITY: Hawaiian Islands.

DISTRIBUTION: Somewhat rare, on moist, wooded mountain slopes and wet flats, at 300–900 m. elevation.

ILLUSTRATIONS: Hook. Sp. Fil. 1: *pl. 29A*. 1841; Bed. Ferns Brit. Ind. *pl. 83*. 1865.

SPECIMENS EXAMINED: Hawaii, *Beratz* B; *Lydgate* B; *Robinson 201* V; *207* V; Maui, *Bailey* C; Molokai, *Hillebrand* B; C; Oahu, *Beechey* C, K; *Diell* C, K; *Baldwin* N; Kauai, *Forbes 34* BM; *356* BM; *Heller 2818; Knudsen* B; *Lydgate* B; *Mann & Brigham 543* N; Hawaiian Islands, *Baldwin 4a* B; *4* C; ex Herb. Mt. Holyoke College C; ex Herb. John Donnell Smith N; *Wilkes Expedition 1* C.

4. HYMENOPHYLLACEAE

Delicate ferns, the leaf blades seldom more than one layer of cells in thickness except at the veins; found in very moist localities, usually above 500 m. in elevation in the tropics. Rootstock slender, creeping or suberect; leaf blades much divided; sporangia sessile upon a filiform, usually elongated receptacle within an urn-shaped, tubular, or two-lipped marginal indusium, or protruding beyond it; annulus complete, transverse, opening vertically.

Receptacle filiform, projecting beyond the indusium. 1. *Trichomanes.*
Receptacle shorter than the indusium, or barely protruding. 2. *Hymenophyllum.*

1. TRICHOMANES L. Sp. Pl. 1097. 1753

Rootstock slender, creeping, or suberect; leaves pinnatifid to tripinnate; veins free; sori terminal upon the veins; indusium tubular or urn-shaped, occasionally 2-lipped; sporangia sessile, arranged spirally upon the receptacle, which usually projects from the margin of the leaf like a trichome.

Type species: *Trichomanes crispum* L.

Stem erect; leafstalk and midrib fibrillose; plants mostly terrestrial. *T. Bauerianum.*
Stem creeping; plants mostly epiphytic, smooth or nearly so.
    Leaf palmate or orbicular, less than 2 cm. high. *T. parvulum.*
    Leaf not palmate nor orbicular, more than 2 cm. high.

Leaf light green, less than 6 cm. high, lanceolate or oblong-lanceolate. *T. humile.*
Leaf dark green, more than 6 cm. high.
  Leaf deltoid. *T. cyrtotheca.*
  Leaf irregular in outline, usually narrowing below. *T. radicans.*

TRICHOMANES BAUERIANUM Endl. Prod. Fl. Norf. 17. 1833

Trichomanes apiifolium Presl, Hym. **16**: 44. 1843.
Trichomanes eminens Presl, Hym. **16**: 44. 1843.
Trichomanes myrioplazium Kunze, Bot. Zeit. **4**: 477. 1846.
Trichomanes meifolium Brack. Fil. U. S. Expl. Exp. 259. 1854.

TYPE LOCALITY unknown.

DISTRIBUTION: On ground in wet forests; Polynesia.

SPECIMENS EXAMINED: Hawaii, *Beratz* B; *Wilkes Expedition* B, C; Molokai, *Hillebrand* B; Maui, *Robinson 381* V; Oahu, *Forbes* BM; *Macrae* B; *Robinson 507* V; Kauai, *Heller 2179* B; *2741* B; *Johnson* B; *Remy 51* B; *Robinson 469* V.

The bilabiate form of the indusium of *T. Bauerianum* Endl. gives the appearance of *Hymenophyllum* to the young leaves, but the projecting vein with its attached sporangia and the urn-shaped form of the mature sporangium place the species in the genus *Trichomanes*.

TRICHOMANES PARVULUM Poir. in Lam. Encyc. 8: 33. 1808

Trichomanes sibthorpioides Gaud. Bory in Willd. Sp. Pl. **5**: 498. 1810.
Trichomanes bifolium Bl. Enum. Pl. 223. 1828.
Trichomanes minutum Bl. Enum. Pl. 224. 1828.
Trichomanes saxifragoides Presl, Hym. 39. 1843.
Gonocormus saxifragoides v. d. Bosch, Hym. 9. 1861.

TYPE LOCALITY unknown.

DISTRIBUTION: Somewhat rare, on tree trunks in moist woods at 600–1,000 m. elevation; Polynesia.

ILLUSTRATION: Hook. Sp. Fil. **1**: 39. 1844.

SPECIMENS EXAMINED: Maui, *Bailey* C; Oahu, *Forbes 1083* BM; *Robinson 53* V; *502* V; *509* V; Hawaiian Islands, *Baldwin 106* B; *107* C; *Hillebrand* B; C; *Wilkes Expedition* C.

The dark green fronds appressed upon the tree trunks or upon the rocks where water is trickling over them, make a beautiful matted covering, which resembles a liverwort in general appearance.

TRICHOMANES HUMILE Forst. Prod. 84. 1786

Trichomanes minutulum Gaud. Freyc. Voy. Bot. 377. *pl. 12. f. 2.* 1827.

Didymoglossum humile Presl, Hym. 23. 1843.

Trichomanes Endlicherianum Presl, Abh. Böhm. Ges. 5: 333. 1848.

Trichomanes Draytonianum Brack. Fil. U. S. Expl. Exp. 252. 1854.

Type locality: Society Islands.

Distribution: On tree trunks in moist woods; Polynesia, Java, Formosa, New Zealand, Australia.

Illustrations: Presl, Epim. 10. *pl. 5A.* 1849; v. d. Bosch, Hym. Java *pl. 11.* 1861; Brack. Fil. U. S. Expl. Exp. *pl. 36.* 1854.

Specimens examined: Maui, *Bailey* C; Oahu, *Robinson 55* V; *99* V; Kauai, *Heller 2556* C; Hawaiian Islands, *Baldwin 108* C; *Remy 83* B; *Wilkes Expedition 9* B, C.

TRICHOMANES CYRTOTHECA Hilleb. Fl. Haw. Is. 636. 1888

Type locality: Kahana, Oahu.

Distribution: Above 600 m. elevation; Hawaiian Islands, in wet woods.

Illustration: Plate 19.

Specimens examined: Maui, *Bailey* C; Oahu, *Hillebrand* B; *Robinson 107* V; Hawaiian Islands, *Baldwin* B; *Baldwin 106* C.

The color and size of the leaves are similar in *T. cyrtotheca* and *T. radicans* and both grow in deep wet forests, but they may be distinguished by the deltoid form of the leaf blade, the curving of the sori, and the smaller size of the rootstock of the former and the irregular outline, blunt pinnae with sori subimmersed, and thicker rhizome of the latter.

TRICHOMANES RADICANS Sw. Jour. Bot. Schrad. 1800^2: 97. 1801

Trichomanes speciosum Willd. Sp. Pl. 5: 514. 1810.

Trichomanes davallioides Gaud. Bot. Freyc. Voy. 3. 1827.

Trichomanes sandvicense v. d. Bosch, Ned. Kr. Arch. 5^2: 165. 1861.

Type locality: West Indies.

Distribution: Tropical countries, Ireland, Wales.

ILLUSTRATION: PLATE 20.

SPECIMENS EXAMINED: Hawaii, *Robinson 250* V; *270* V; *290* V; Maui, *Bailey* C; *Robinson 310* V; Oahu, *Didrichsen* C; *Forbes 95* BM; *Heller 2119* C; *Macrae* B; *Robinson 76* V; *108* V; Kauai, *Hillebrand* B; Hawaiian Islands, *Baldwin 109a* B, C; *Bennett* B; *Gaudichaud* B; *Lydgate* B; *Remy 52* B; *Wilkes Expedition 12* B, C (cotype of *T. sandvicense* v. d. Bosch).

Sir James E. Smith says "Few plants of any country have caused more enquiry or more diversity of opinion than this fern," and the variations in the Hawaiian forms of this species might add much material for such discussion.

2. HYMENOPHYLLUM J. E. Smith, Mém. Acad. Turin 5: 418. 1793

Rootstock slender, creeping; leaves pinnatifid to bipinnatifid, glabrous or hairy; sori terminal upon the veins; indusium bilabiate, formed by the division of the tissue of the margin of the leaf; receptacle seldom exserted.

Type species: *Hymenophyllum tunbridgense* (L.) Sm.

- Stem upright; leaves tufted, lanceolate; leafstalk clothed with reddish hairs. *H. Baldwinii.*
- Stem creeping; leaves not tufted.
  - Leaves glabrous, the apexes usually curving downward. *H. recurvum.*
  - Leaves hairy, the apexes vertical.
    - Leaves rhomboid or obtuse-ovate, covered with reddish brown stellate hairs. *H. obtusum.*
    - Leaves lanceolate, bearing simple hairs on margin and veins. *H. lanceolatum.*

HYMENOPHYLLUM BALDWINII D. C. Eaton, Bull. Torrey Club 6: 293. 1879

TYPE LOCALITY: Oahu.

DISTRIBUTION: On trees, above 800 m. elevation, in a lateral valley of Nuuanu, which leads up to Konahuanui.

SPECIMENS EXAMINED: ex Herb. D. C. Eaton (cotype) C; *Baldwin 110* C; *Baldwin* V.

HYMENOPHYLLUM RECURVUM Gaud. Voy. Freyc. Bot. 376. 1832

TYPE LOCALITY: Maui, Hawaiian Islands.

DISTRIBUTION: On trees above 600 m. elevation, Hawaiian Islands.

ILLUSTRATION: Hook. Sp. Fil. **1**: *pl. 37.* 1844.

SPECIMENS EXAMINED: Hawaii, *Robinson 209* V; *215* V; Maui, *Bailey C; Robinson 311* V; *317* V; *326* V; Oahu, *Diell* C; *Heller 2603* C; *2620* C; *Hillebrand* C; *Macrae* B; *Robinson 39* V; *508* V; *Forbes* BM; Kauai, *Forbes 113* BM; *Hillebrand 152* B; *Robinson 835* V; Hawaiian Islands, *Baldwin 102* C; *Beechey* C; *Gaudichaud 195* B; *Lindley* C; *Wilkes Expedition 15* B, C.

Hymenophyllum recurvum is a very graceful fern, which forms a light green covering upon the tree trunks and wet rocks in deep, shady glens.

HYMENOPHYLLUM OBTUSUM Hook. & Arn. Bot. Beech. 109. 1832

TYPE LOCALITY: Oahu.

DISTRIBUTION: On trees, in wet forests, Hawaiian Islands; also reported from New Guinea and Cape of Good Hope.

ILLUSTRATION: Hook. Sp. Fil. **1**: *pl. 37D.* 1844.

SPECIMENS EXAMINED: Molokai, *Hillebrand* B; Oahu, *Heller 2229* C; *2910* C; *Robinson 10* V; *37* V; *503* V; Hawaiian Islands, *Baldwin 104* C; *Wilkes Expedition* C.

HYMENOPHYLLUM LANCEOLATUM Gaud. Voy. Freyc. Bot. 109. 1832

TYPE LOCALITY: Hawaiian Islands.

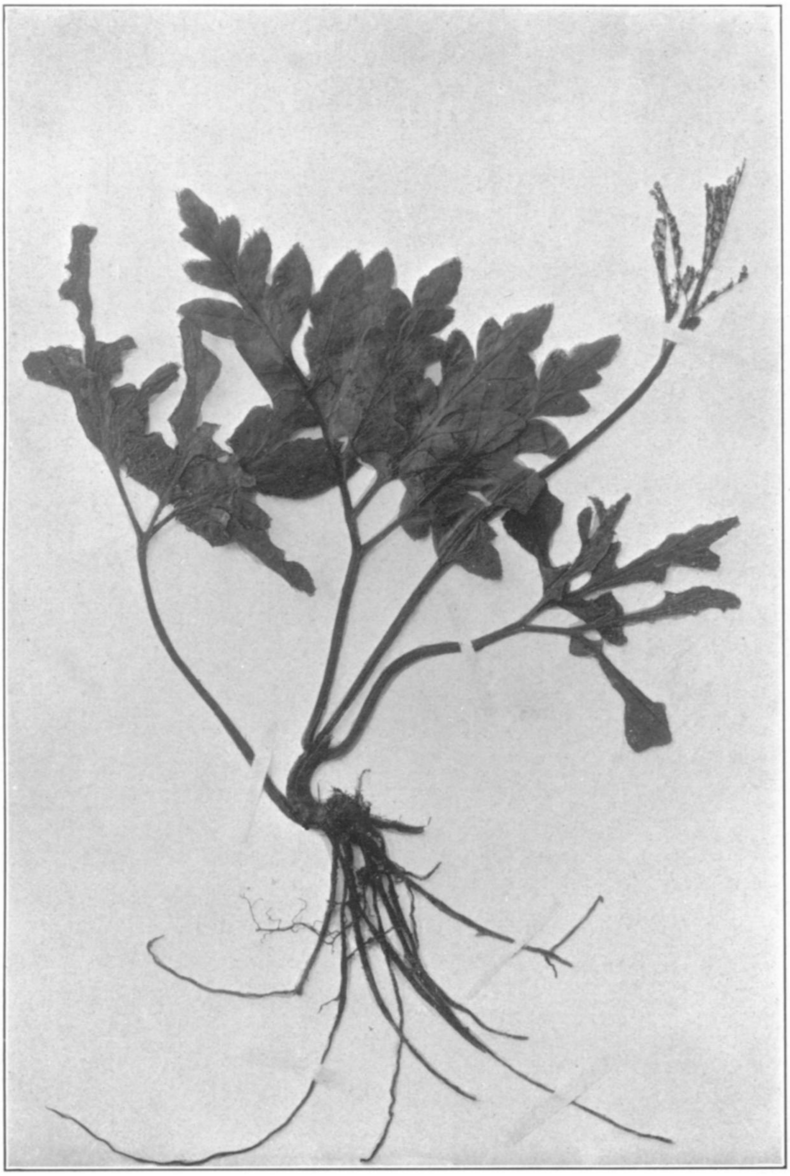
DISTRIBUTION: On tree trunks in Hawaiian Islands.

ILLUSTRATION: Hook. Sp. Fil. *pl. 34.* 1844.

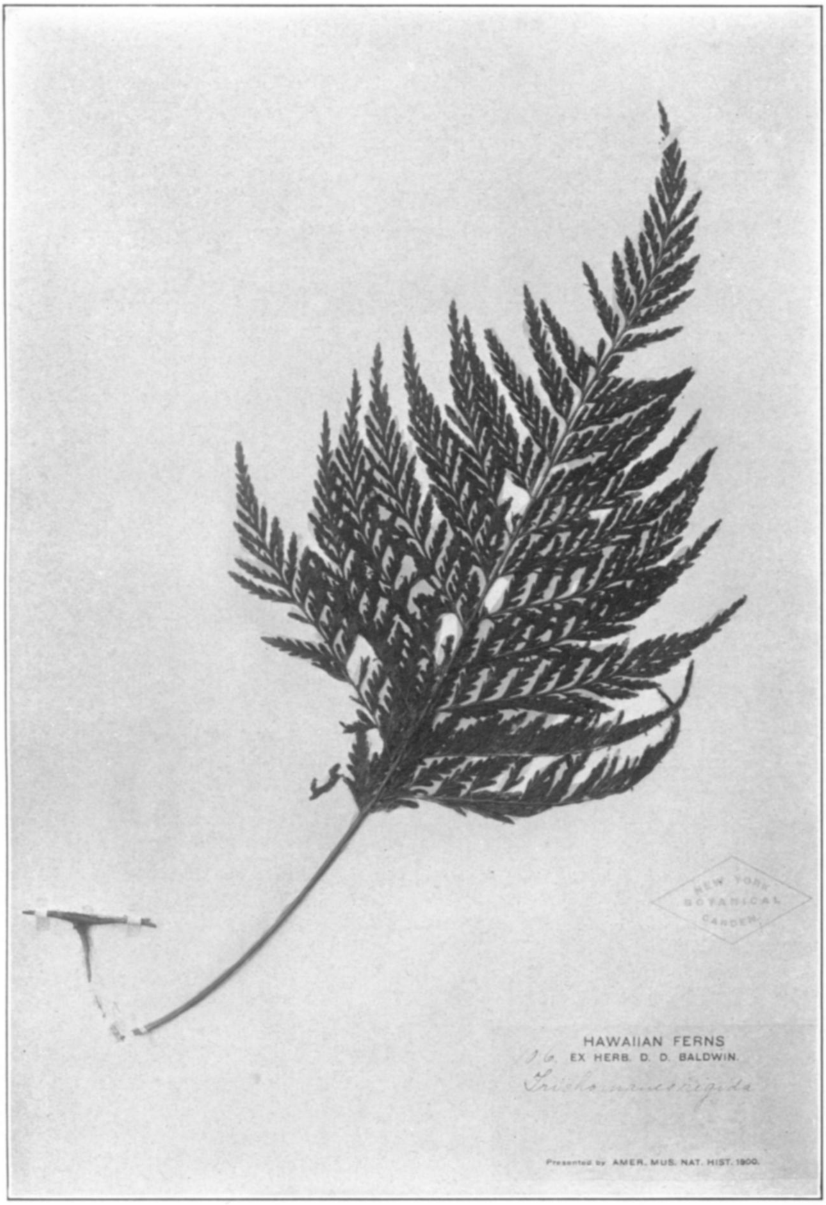
SPECIMENS EXAMINED: Hawaii, *Robinson 273* V; *278* V; Maui, *Bailey* C; Oahu, *Heller 2256* C; *2705* C; *Macrae* B; *Robinson 70* V; *94* V; *96* V; *125* V; Kauai, *Robinson 404* V; *406* V; *830* V; Hawaiian Islands, *Baldwin 103* C; *Douglas* B; *Gaudichaud* B; *Wilkes Expedition* B; C.

The fronds soon become bronze in color, partly from the hairiness of their surface, by which, as well as by their size, they are easily distinguished from *H. recurvum*.

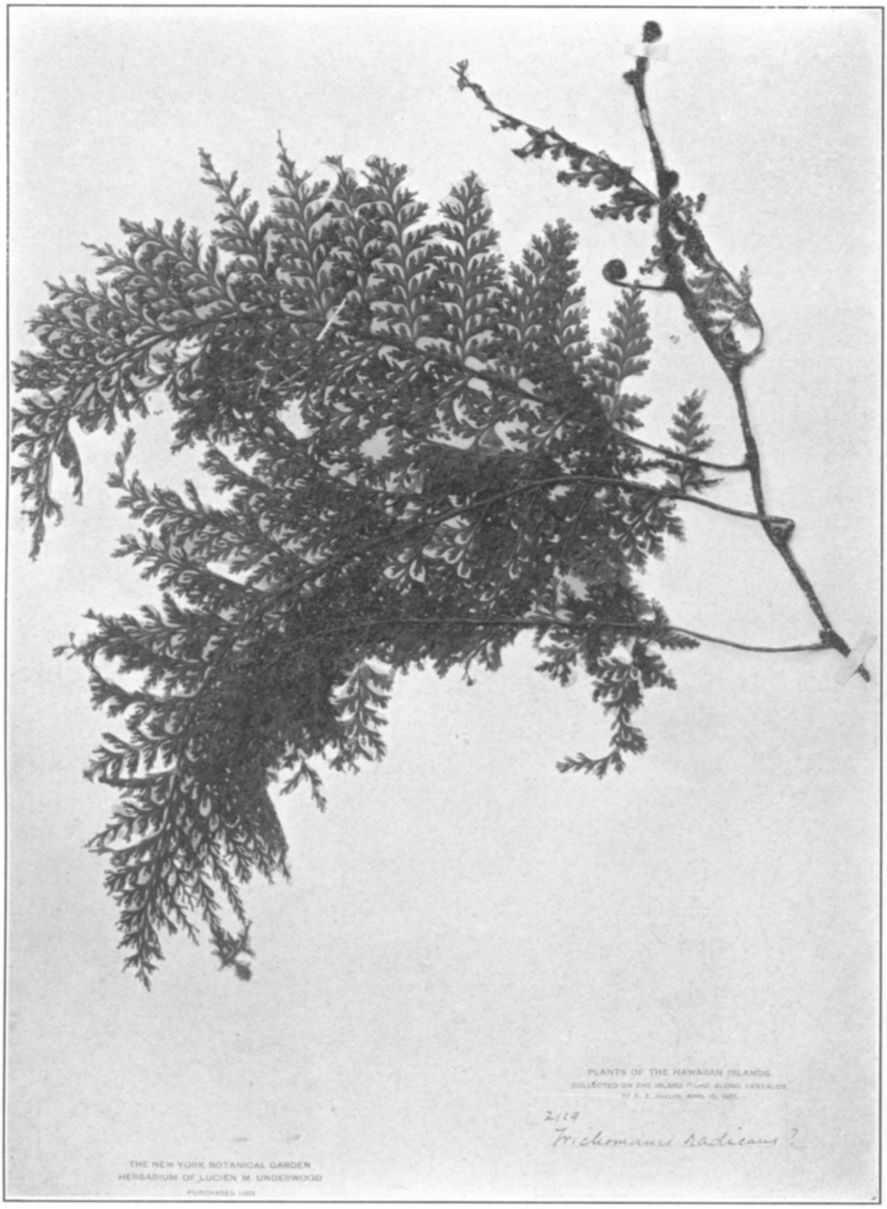
The following specimens are smaller than the others and bear only marginal hairs: *Heller 2705*, *Robinson 302*, *404*, *406*, *830*.



BOTRYCHIUM SUBBIFOLIATUM Brack.


NEW YORK BOTANICAL GARDEN
HAWAIIAN FERNS
106. EX HERB. D. D. BALDWIN.
Trichomanes rigida
Presented by AMER. MUS. NAT. HIST. 1900.

TRICHOMANES CYRTOTHECA Hilleb.


PLANTS OF THE HAWAIIAN ISLANDS
2119
Trichomanes radicans ?
THE NEW YORK BOTANICAL GARDEN
HERBARIUM OF LUCIEN M. UNDERWOOD

TRICHOMANES RADICANS SW.